

## CLAIMS

What is claimed is:

1. A magnetic storage system, comprising:  
a read element; and  
an electrostatic discharge (ESD) protection circuit that comprises a shunting device including a first terminal that communicates with a first terminal of said read element and a second terminal that communicates with a second terminal of said read element,  
wherein said shunting device is conductive when said read element is disabled and nonconductive when said read element is enabled.
2. The magnetic storage system of Claim 1 wherein said ESD protection circuit includes a first voltage limiting circuit that limits voltage that is input to first terminals of said shunting device and said read element.
3. The magnetic storage system of Claim 2 wherein said ESD protection circuit includes a second voltage limiting circuit that limits voltage that is input to second terminals of said shunting device and said read element.

4. The magnetic storage system of Claim 2 wherein said first voltage limiting circuit includes first and second diodes, wherein an anode of said first diode and a cathode of said second diode communicate with said first terminal of said read element and said first terminal of said shunting device and a cathode of said first diode and an anode of said second diode communicate.

5. The magnetic storage system of Claim 3 wherein said second voltage limiting circuit includes third and fourth diodes, a cathode of said third diode and an anode of said fourth diode communicate with said second terminal of said read element and said second terminal of said shunting device, and an anode of said third diode and a cathode of said fourth diode communicate.

6. The magnetic storage system of Claim 1 further comprising first and second current sources, wherein said first terminal of the read element and said first terminal of said shunting device communicate with said first current source and wherein said second terminal of said read element and said second terminal of said shunting device communicate with said second current source.

7. The magnetic storage system of Claim 1 further comprising a third voltage limiting circuit that limits a voltage drop across said first and second terminals of said shunting device and said read element.

8. The magnetic storage system of Claim 7 wherein said third voltage limiting circuit includes fifth and sixth diodes, wherein a cathode of said fifth diode and an anode of said sixth diode communicate with said first terminal of said read element and said first terminal of said shunting device and wherein an anode of said fifth diode and a cathode of said sixth diode communicate with said second terminal of said read element and said second terminal of said shunting device.

9. The magnetic storage system of Claim 1 wherein said shunting device includes a normally-on transistor.

10. The magnetic storage system of Claim 9 wherein said transistor includes one of a depletion mode metal-oxide semiconductor field-effect transistor (MOSFET) and a JFET.

11. The magnetic storage system of Claim 1 further comprising a preamp circuit, wherein said ESD protection circuit is implemented in said preamp circuit of said magnetic storage system.

12. The magnetic storage system of Claim 1 wherein said read element is one of a magneto-resistive (MR) sensor, a giant magneto-resistive (GMR) sensor, and a tunneling giant magneto-resistive (TGMR) sensor.

13. The magnetic storage system of Claim 1 wherein a voltage tolerance of said read element is less than 0.4 volts.

14. An electrostatic discharge (ESD) protection circuit for a read element in a magnetic storage system, comprising:

a shunting device that includes:

a first terminal that communicates with a first terminal of the read element; and

a second terminal that communicates with a second terminal of the read element,

wherein said shunting device provides a conductive path between said first and second terminals of said shunting device when the read element is disabled and a nonconductive path between said first and second terminals of said shunting device when the read element is enabled.

15. The ESD protection circuit of Claim 14 further comprising a first voltage limiting circuit that limits a maximum voltage that is applied to said first terminal of said shunting device.

16. The ESD protection circuit of Claim 14 wherein said first voltage limiting circuit includes first and second diodes, wherein an anode of said first diode and a cathode of said second diode communicate with a first terminal of said shunting device and a cathode of said first diode and an anode of said second diode communicate.

17. The ESD protection circuit of Claim 14 further comprising a second voltage limiting circuit that limits a voltage that is applied to a second terminal of said shunting device.

18. The ESD protection circuit of Claim 17 wherein said second voltage limiting circuit includes third and fourth diodes, a cathode of said third diode and an anode of said fourth diode communicate with a second terminal of said shunting device, and an anode of said third diode and a cathode of said fourth diode communicate.

19. A magnetic storage system comprising the ESD protection circuit of Claim 14 and further comprising first and second current sources, wherein said first terminal of said shunting device communicates with a first current source and said second terminal of said shunting device communicates with a second current source.

20. The ESD protection circuit of Claim 14 further comprising a third voltage limiting circuit that limits a voltage drop across said first and second terminals of said shunting device.

21. The ESD protection circuit of Claim 20 wherein said third voltage limiting circuit includes fifth and sixth diodes, wherein a cathode of said fifth diode and an anode of said sixth diode communicate with said first terminal of said shunting device and wherein an anode of said fifth diode and a cathode of said sixth diode communicate with said second terminal of said shunting device.

22. The ESD protection circuit of Claim 14 wherein said shunting device includes a normally-on transistor.

23. The ESD protection circuit of Claim 22 wherein said transistor is one of a depletion mode metal-oxide semiconductor field-effect transistor (MOSFET) and a JFET.

24. A magnetic storage system comprising the ESD protection circuit of Claim 14 and further comprising said read element.

25. The magnetic storage system of Claim 24 wherein said read element is one of a magneto-resistive (MR) sensor, a giant magneto-resistive (GMR) sensor, and a tunneling giant magneto-resistive (TGMR) sensor.

26. The magnetic storage system of Claim 24 wherein a voltage tolerance of said read element is less than 0.4 volts.

27. A magnetic storage system, comprising:

reading means for reading magnetic fields; and

electrostatic discharge (ESD) protecting means that comprises a shunting means for shunting and including a first terminal that communicates with a first terminal of said reading means and a second terminal that communicates with a second terminal of said reading means,

wherein said shunting means is conductive when said reading means is disabled and nonconductive when said reading means is enabled.

28. The magnetic storage system of Claim 27 wherein said ESD protecting means includes first voltage limiting means for limiting a voltage input to first terminals of said shunting means and said reading means.

29. The magnetic storage system of Claim 28 wherein said ESD protecting means include second voltage limiting means for limiting a voltage input to second terminals of said shunting means and said reading means.



30. The magnetic storage system of Claim 28 wherein said first voltage limiting means includes first and second diodes, wherein an anode of said first diode and a cathode of said second diode communicate with said first terminal of said reading means and said first terminal of said shunting means and a cathode of said first diode and an anode of said second diode communicate.

31. The magnetic storage system of Claim 29 wherein said second voltage limiting means includes third and fourth diodes, a cathode of said third diode and an anode of said fourth diode communicate with said second terminal of said reading means and said second terminal of said shunting means, and an anode of said third diode and a cathode of said fourth diode communicate.

32. The magnetic storage system of Claim 27 further comprising first and second current means for providing current, wherein said first terminal of the reading means and said first terminal of said shunting means communicate with said first current means and wherein said second terminal of said reading means and said second terminal of said shunting means communicates with said second current means.

33. The magnetic storage system of Claim 27 further comprising third voltage limiting means for limiting a voltage drop across said first and second terminals of said shunting means and said reading means.

34. The magnetic storage system of Claim 33 wherein said third voltage limiting means includes fifth and sixth diodes, wherein a cathode of said fifth diode and an anode of said sixth diode communicate with said first terminal of said reading means and said first terminal of said shunting means and wherein an anode of said fifth diode and a cathode of said sixth diode communicate with said second terminal of said reading means and said second terminal of said shunting means.

35. The magnetic storage system of Claim 27 wherein said shunting means includes a normally-on transistor.

36. The magnetic storage system of Claim 33 wherein said transistor is one of a depletion mode metal-oxide semiconductor field-effect transistor (MOSFET) and a JFET.

37. The magnetic storage system of Claim 27 further comprising a preamp means for amplifying a signal output by said reading means, wherein said ESD protecting means is implemented in said preamp means of said magnetic storage system.

38. The magnetic storage system of Claim 27 wherein said reading means is one of a magneto-resistive (MR) sensor, a giant magneto-resistive (GMR) sensor, and a tunneling giant magneto-resistive (TGMR) sensor.

39. The magnetic storage system of Claim 27 wherein a voltage tolerance of said reading means is less than 0.4 volts.

40. An electrostatic discharge (ESD) protecting circuit for a read element in a magnetic storage system, comprising:

shunting means for protecting the read element from ESD and that includes:

a first terminal that communicates with a first terminal of the read element; and

a second terminal that communicates with a second terminal of the read element,

wherein said shunting means provides a conductive path between said first and second terminals of said shunting means when the read element is disabled and a nonconductive path between said first and second terminals of said shunting means when the read element is enabled.

41. The ESD protection circuit of Claim 40 further comprising first voltage limiting means for limiting a maximum voltage that is applied to said first terminal of said shunting means.

42. The ESD protection circuit of Claim 40 wherein said first voltage limiting means includes first and second diodes, wherein an anode of said first diode and a cathode of said second diode communicate with a first terminal of said shunting means and a cathode of said first diode and an anode of said second diode communicate.

43. The ESD protection circuit of Claim 40 further comprising second voltage limiting means for limiting a voltage that is applied to a second terminal of said shunting means.

44. The ESD protection circuit of Claim 43 wherein said second voltage limiting means includes third and fourth diodes, a cathode of said third diode and an anode of said fourth diode communicate with a second terminal of said shunting means, and an anode of said third diode and a cathode of said fourth diode communicate.

45. A magnetic storage system comprising the ESD protection circuit of Claim 40 and further comprising first and second current means for supplying current, wherein said first terminal of said shunting means communicates with a first current means and said second terminal of said shunting means communicates with a second current means.

46. The ESD protection circuit of Claim 40 further comprising third voltage limiting means for limiting a voltage drop across said first and second terminals of said shunting means.

47. The ESD protection circuit of Claim 46 wherein said third voltage limiting means includes fifth and sixth diodes, wherein a cathode of said fifth diode and an anode of said sixth diode communicate with said first terminal of said shunting means and wherein an anode of said fifth diode and a cathode of said sixth diode communicate with said second terminal of said shunting means.

48. The ESD protection circuit of Claim 40 wherein said shunting means includes a normally-on transistor.

49. The ESD protection circuit of Claim 48 wherein said transistor is one of a depletion mode metal-oxide semiconductor field-effect transistor (MOSFET) and a JFET.

50. A magnetic storage system comprising the ESD protection circuit of Claim 40 and further comprising said read element.

51. The magnetic storage system of Claim 50 wherein said read element is one of a magneto-resistive (MR) sensor, a giant magneto-resistive (GMR) sensor, and a tunneling giant magneto-resistive (TGMR) sensor.

52. The magnetic storage system of Claim 50 wherein a voltage tolerance of said read element is less than 0.4 volts.

53. A method of operating a magnetic storage system, comprising:  
reading magnetic fields using a read element having first and second terminals; and  
shorting said first and second terminals of said read element when said reading means is disabled.

54. The method of Claim 53 further comprising:  
using a shunting device to perform said shorting step; and  
limiting a voltage input to a first terminal of said shunting device and said first terminal of said read element.

55. The method of Claim 53 further comprising limiting a voltage input to second terminals of said shunting device and said read element.

56. The method of Claim 53 further comprising limiting a voltage drop across said first and second terminals of said shunting device and said read element.

57. The method of Claim 54 wherein said shunting device includes a normally-on transistor.

58. The method of Claim 57 wherein said transistor includes one of a depletion mode metal-oxide semiconductor field-effect transistor (MOSFET).

59. The method of Claim 53 wherein said read element is one of a magneto-resistive (MR) sensor, a giant magneto-resistive (GMR) sensor, and a tunneling giant magneto-resistive (TGMR) sensor.

60. The method of Claim 53 wherein a voltage tolerance of said read element is less than 0.4 volts.



61. A method of providing electrostatic discharge (ESD) protection for a read element in a magnetic storage system, comprising:

coupling a first terminal of a shunting device to a first terminal of the read element;

coupling a second terminal of said shunting device to a second terminal of the read element,

providing a conductive path between said first and second terminals of said shunting device when the read element is disabled; and

providing a nonconductive path between said first and second terminals of said shunting device when the read element is enabled.

62. The method of Claim 61 further comprising limiting a voltage that is applied to said first terminal of said shunting device.

63. The method of Claim 61 further comprising limiting a voltage that is applied to a second terminal of said shunting device.

64. The method of Claim 61 further comprising limiting a voltage drop across said first and second terminals of said shunting device.

65. The method of Claim 61 wherein said read element is one of a magneto-resistive (MR) sensor, a giant magneto-resistive (GMR) sensor, and a tunneling giant magneto-resistive (TGMR) sensor.

66. The method of Claim 61 wherein a voltage tolerance of said read element is less than 0.4 volts.